

Demarcation of juvenile and mature woods of planted Chinese fir and its wood quality prediction

Li Jian (李坚) Liu Yixing (刘一星) Cui Yongzhi (崔永志) Xu Zicai (徐子才)
Northeast Forestry University, Harbin 150040, P. R. China

Abstract According to the data of trashed length, micro fiber angle, air density, ring width and late wood percentage, with the analysis of optimum method of classification, the boundary line of juvenile wood and mature wood of planted Chinese fir (*Cunninghamia lanceolata*) was determined as the 14th year. Based on the variation pattern of these parameters, the prediction equations were established. Wood quality prediction can be realized by these equations. By error analysis between the values of measured data and the values of prediction data, it is found that the results of wood prediction of planted Chinese fir are satisfactory.

Key word: Planted Chinese fir, Juvenile wood, Wood quality prediction

Introduction

Chinese fir (*Cunninghamia lanceolata*(Lamb.) Hook) is a very important species of wood resources in Southern China. The heredity and amelioration on Chinese fir are always paid great attention. However, in the past, the focal point of the work on heredity and amelioration was how to cultivate the Chinese fir with characters of fast growth, good figure, wide adaptability and strong disease resistance. Little work was done on amelioration of wood quality. Along with the composition change of the forest resources in China, Chinese wood industry is more dependent on short-term planted trees. Because wood utilization get benefits from wood amelioration directly, it is important to master the variation pattern and mature age of these major trees.

Material and method

Collection of testing wood

The samples of Chinese fir in this research are collected from Xitan Forestry Farm, Anfu County, Jiangxi Province. The selected trees are planted trees that are 27 years old and grow in soil with red-yellow color. Samples were collected in December 8, 1991. The topography where the sample trees grow is southern slope. The basic conditions of samples are showed in Table 1. Three slices were chosen. The lowest slice is from the sample tree with 1.0 m in height. The first and second ring can not be found in this slice, so the third ring is the beginning and the 27th ring is the last ring in this research.

Sample preparation and measuring method

Sample selection was done according to the Chinese

national criterion, "Selection Method of Testing Sample of Wood Physics and Mechanics". The long direction of sample is east to west.

Table 1. Sample condition

Slice Number	Tree number	Slice height	Tree height	The first branch height
111		1.0		
112	1	3.0	17.7	9.7
113		5.0		
121		1.0		
122	2	3.0	29.0	8.0
123		5.0		
131		1.0		
132	3	3.0	16.8	7.8
133		5.0		
151		1.2		
152	4	3.2	17.7	8.2
153		5.2		
1101		1.0		
1102	10	3.1	19.0	8.0
1103		5.2		

For air density, we took sticks with cross section of 0.8 cm × 0.8 cm along radial direction from each sample respectively and grind the sticks with abrasive paper, then sever each ring lump of the stick, count and weight each ring lump, cover the lumps with paraffin wax, and last, measure the volume of each numbered lump with method of drain off water. Trashed length was measured by Section Method of Ladle. Micro fiber angle was measured by method of iodine dye. Ring width and late wood percentage parameters were measured by using Length Micro-meter with precision of 0.01 m. Percentage of thickness of cell wall (PTCW) was measured by using Computer Visual Image Operation System.

Demarcation of juvenile and mature woods

Commonly, the growth of all trees goes through juvenile period, mature period and senile period.

The wood formed in different period differs greatly in quality. By comparing juvenile wood and mature wood, it is general that the density is lower, trashed length shorter, micro fiber angle bigger, dry shrinkage bigger and strength is lower in juvenile wood than those of mature wood. Because of these differences, the boundary line of juvenile and mature woods must be considered whether in the area of wood processing or in determining the logging period of trees. Therefore, having reasonable demarcation on this boundary line is very important. In this research, the analysis of optimum method of classification was adopted. This analytical method based on the condition of reserving the sequence of samples and the rule that the sum of squares of deviation is smaller in same kind of samples and the sum of squares of deviation is larger in different kinds of samples, especially to realize wood quality perdition. We measured the traced length, micro fiber angle, air density, ring width and the late wood percentage of Chinese fir with the analysis of optimum method of classification. We also determined the boundary line of juvenile wood and mature wood of planted Chinese fir. The conclusion in this paper provided a theoretical basis for utilizing planted Chinese fir and determining the optimum logging period reasonably.

For long period, many forest scientists have been

Table 2. The results of classification of each wood parameter

Parameter	Results of classification																										
	First catalogue											Second catalogue															
Trashed length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Micro fiber angle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Air density	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Ring width	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Late wood percentage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Comprehensiveness	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27

Prediction of wood quality

The principle and method

Wood quality prediction is new research area. So far, little researches were reported in this area. Wood quality prediction is the quantitative prediction that can predict the future developing trend of mature wood nature by parameters of juvenile wood. During growth of wood, wood developing trend is effected and controlled by many factors. The wood characters of different species, different parts or in different places have significant differences. So wood quality prediction is a relatively hard work. But wood variation processes some rules. Basing on these rules, wood

working on and attributing a lot to the research on wood physics and mechanics, basic anatomical nature and heredity of Chinese fir. However, little studies were conducted on wood quality prediction.

According to the variation pattern of the parameters of wood anatomy and physics of Chinese fir, we made regression for the mathematical models that represent the common ones. The quality of mature wood can be predicted by the parameters of juvenile wood. In short, the result of the paper is very valuable to the defective breeding and resource utilization of planted Chinese fir. This research is a branch of the program on variation pattern of wood quality prediction and mature term determination of short-term industrial wood during its growth. In the past, it is usually to adopt the method of trend observation to demarcate the boundary line artificially. This method not only brings bigger error, but also possibly makes the results lack fidelity. In addition, the method of trend observation can not classify each parameter comprehensively. However, the analysis of optimum method of classification completely overcomes these defects. It is accurate and reliable. Mean while, it can analyzes each parameter comprehensively. In this research, the trashed length, micro fiber angle, air density, ring width and percentage of late wood on three parts located in different heights of 5 trees of Chinese fir were tested and measured. Then all the tested parameters were classified orderly. The results were shown in Table 2. By comprehensive classification, the boundary line of juvenile and mature woods of Chinese fir was determined to be the 14th year.

quality prediction can be realized. Firstly, the necessary conditions of wood quality perdition are the variation patterns of wood parameters along ring are evident. Secondly, the boundary line of juvenile and mature wood can be determined. Thirdly, the variation patterns of juvenile and mature wood are similar. The method of statistical analysis was used to predict nature of mature wood by juvenile wood. Basing on testing data of samples, regression equations were obtained (Table 3), then according the pattern of these regression equations and parameters of juvenile wood (first 13 years), the prediction equations were established (Table 4) so predicting data can be obtained (see Fig. 1, 2, 3, 4, 5).

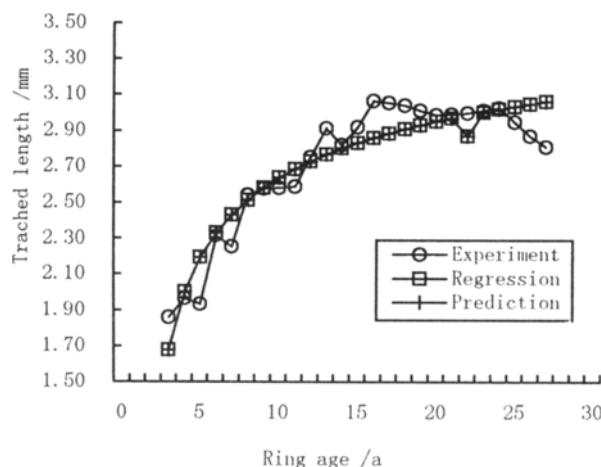


Fig. 1. Variation, regression and prediction curve of thatched length of Chinese fir along radial direction

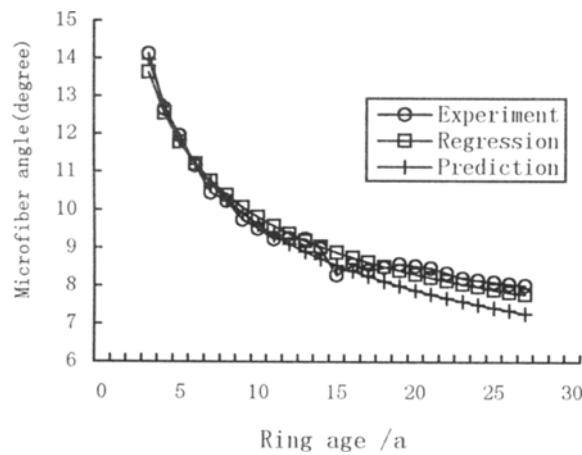


Fig. 2. Variation, regression and prediction curve of micro fiber angle of Chinese fir along radial direction

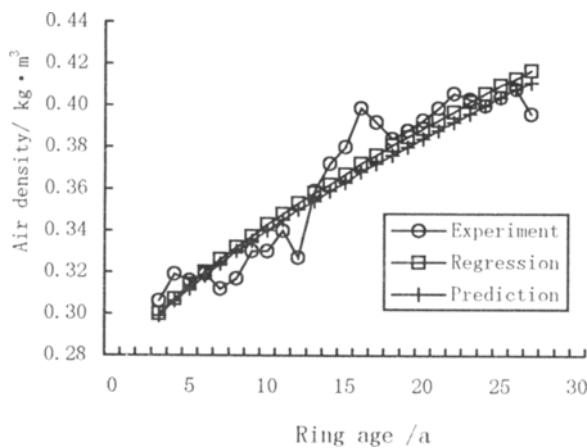


Fig. 3. Variation, regression and prediction curve of air density of Chinese fir along radial direction

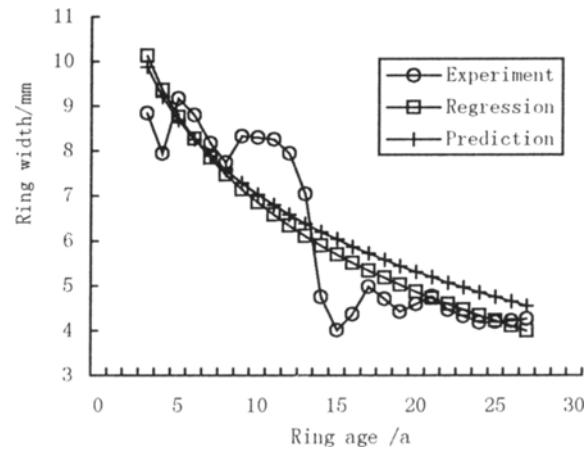


Fig. 4. Variation, regression and prediction curve of ring width of Chinese fir along radial direction

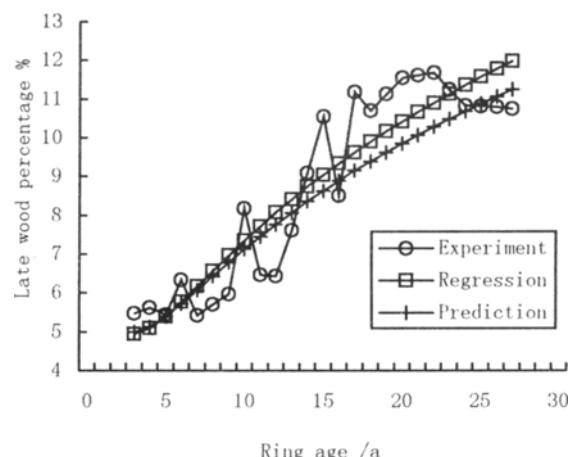


Fig. 5. Variation, regression and prediction curve of late wood percentage of Chinese fir along radial direction

In practical application, the prediction method in this research can be realized by taking vegetative cone. The effect of prediction can be evaluated by comparing the testing data and prediction data. Thus, this method is practical and effective. Mr Ye Peizhong had researched the early selection of Chinese fir. He selected superior height growth amount as the parameters of prediction and got a good effect. So he believed that the wood quality prediction of Chinese fir was feasible. Mr Mohridiek, in his research of the regression analysis of early and late term wood in 1979, confirmed that growth trend of hybrid tree can be predicted. In addition, Mr Nanson, considered that the height of one-year old seedling of *Pinus sylvestris* var. *mongolica* can be one of prediction parameters by testing the parameters of Chinese fir. This research confirm further that the wood quality prediction

of planted Chinese Fir is viable.

Table 3. Regression equation of each parameter

Parameter	Regression equation	Relation coefficient
Trashed length	$Y = 1.522327 + 1.313928[\ln(\ln X)]^{0.9}$	0.942155
Micro fiber angle	$Y = 3.6073135 + 15.55998/X^{0.4}$	-0.987003
Air density	$Y = 0.268813 + 0.014834/X^{0.7}$	0.946326
Ring width	$Y = 62.92292 - 49.9733X^{0.05}$	-0.882455
Late wood percentage	$Y = 4.94619 + 4.145093[\ln(\ln X)]^3$	0.920803

Table 4. Prediction model of each parameter

Parameter	Prediction equation
Trashed	$Y = A + B [\ln(\ln X)]^{0.9}$
Micro fiber angle	$Y = A + B/X^{0.4}$
Air density	$Y = A + BX^{0.7}$
Ring width	$Y = A + BX^{0.05}$
Late wood percentage	$Y = A + B [\ln(\ln X)]^3$

Table 5. Prediction equations and errors between measuring data and prediction data

Parameter	Prediction equation	Average relative error %	Average relative standard error %
Trashed length	$y = 1.530763 + 1.265527[\ln(\ln X)]^{0.9}$	3.9267	78.1284
Micro fiber angle	$y = 2.516074 + 17.78359/X^{0.4}$	6.1524	6.9250
Air density	$y = 0.269011 + 0.01423/X^{0.7}$	2.8152	3.659
Ring width	$y = 55.59931 - 43.2865X^{0.05}$	15.4651	23.2675
Late wood percentage	$y = 4.993567 + 3.679764[\ln(\ln X)]^3$	10.0631	14.4548

Conclusion

By analyzing each wood parameters with the analysis of optimum method of classification, it is determined that the boundary line of Juvenile wood and mature wood of planted Chinese Fir is the 14th year. The wood formed before the 14th year is juvenile wood. The wood formed on or after the 14th year is mature wood. Variation models of parameters of Chinese Fir are respectively:

Trashed length,	$Y=A+B [\ln(\ln X)]^{0.9}$
Micro fiber angle,	$Y=A+B/X^{0.4}$
Air density,	$Y=A+BX^{0.7}$
Ring width,	$Y=A+BX^{0.05}$
Late Wood Percentage,	$Y=A+B [\ln(\ln X)]^3$

Based on the variation pattern of tested parameters, the prediction equations can be established. Therefore wood quality production of Chinese Fir can be realized. By error analysis between the values of measured data and the values of prediction data, it is confirmed that the prediction method in this research is feasible, the ideal effect of prediction is on micro fiber angle, trashed length and air density.

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Prediction result evaluation and analysis of prediction possibility

By comparing the measuring data and prediction data, the results of prediction can be evaluated. Table 5 shows the errors of prediction of each parameter. Among the relative errors, the error of ring width is the highest, and the error of late wood percentage is the second highest. Among the relative standard errors, the highest error is also in ring width. From this, we can see that ring width is less possible to be predicted. Late wood percentage has close relation with ring width, so late wood percentage fluctuate are more than other parameters and its prediction result is not very good. From the two kinds of errors, it can be seen that the errors of other parameters are very low. So their prediction effects are ideal.

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